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Running head: Predictors of late personality change

**Correlates of personality trait levels and their changes in very old age: The Lothian  
Birth Cohort 1921**

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**Abstract**

We tested the associations between individual differences in the Big Five personality traits and their changes over the ninth decade of life and levels of and changes in cognitive functioning, physical fitness, and everyday functioning. Besides mean-level changes in personality traits, there were significant individual differences in their rates of change between ages 81 and 87. The changes in the Big Five traits were not strongly intercorrelated, suggesting little common influence on personality change. Lower IQ at age 79 predicted lower Intellect and higher Extraversion, and more decline in Conscientiousness from ages 81 to 87. Also, decreases in physical fitness were associated with declines in Conscientiousness.

**Keywords:** Personality development; Big Five; personality change; correlated change; old age.

## 1. Introduction

In addition to individual differences in personality trait *levels* as they are measured at any particular time, there are individual differences in the extent of personality trait *changes* over time (Small, Hertzog, Hultsch, & Dixon, 2003). This confers a need to look for possible influences on individual personality trait change trajectories, which may inform us about the trait development of individual people but also about general patterns of personality trait development such as mean-level changes. In particular, it has been suggested that mean-level changes in personality traits are brought about by people moving through various life-periods that are characterized by relatively age-specific experiences at more or less similar times in their life courses (Roberts, Wood, & Smith, 2005). If so, then people who are engaged in the age-characteristic experiences to a greater/lesser degree than is typical should display personality trait change that is different from the normative pattern.

Individual differences in personality trait change at various stages of adulthood have been meaningfully traced to a number of predictors such as starting a marriage (Specht, Egloff, & Schmukle, 2011), marital success or disruption or death of spouse (Mroczek & Spiro, 2003; Roberts, Helson, & Klohnen, 2002; Specht et al., 2011), child birth (Specht et al., 2011), work-related experiences (Helson & Picano, 1990; Roberts, Caspi, & Moffitt, 2003; Roberts, Walton, Bogg, & Caspi, 2006), life-satisfaction and coping with age-specific concerns such as children's problems (van Aken, Denissen, Branje, Dubas, & Goossens, 2006), self-reported traumatic experiences (Löckenhoff, Terracciano, Patriciu, Eaton, & Costa, 2009), and cognitive problems (Mroczek & Spiro, 2003; Talassi, Cipriani, Bianchetti, & Trabucchi, 2007). Several of the listed correlates of personality change (e.g., marriage, child-birth or cognitive problems) can be seen as relatively age-specific life-events or experiences, suggesting that they may be among the potential contributors to commonly observed mean-level changes such as general declines in Extraversion and Openness and

increases in Emotional stability, Agreeableness and Conscientiousness (Lucas & Donnellan, 2009; Roberts, Walton, & Viechtbauer, 2006; Terracciano, McCrae, Brant, & Costa 2005). This, however, is not likely to be an exhaustive list of possible correlates of personality trait change: many of them are probably yet to be discovered, including those that characterize later periods of the life-course and that are not necessarily environment-related experiences but rather reflect intrinsic developmental changes such as the ageing process generally.

### *1.1. Personality trait development in late life*

Compared to younger ages, less is known about personality trait development in old age, especially in the ninth decade of life. One of the few studies in this age group (Möttus, Johnson, & Deary, 2011) was carried out using the same unique sample that we further investigated in the present report: the Lothian Birth Cohort 1921 (LBC1921). In that report (Möttus et al., 2011), substantial changes in personality traits were reported for the ninth decade of life: mean scores on Extraversion, Intellect, Agreeableness and Conscientiousness declined 0.23, 0.23, 0.28, and 0.32 standard deviations within six years, respectively. Compared to the magnitude of mean-level changes reported in a comprehensive meta-analysis (Roberts et al., 2006), there was thus no evidence that mean-level changes slowed down in late life. This suggested that, in general, personality trait development continues in old age. If so, questions regarding individual differences in these changes are also relevant: are there still significant individual differences in personality trait changes, are the changes general (correlated across traits) or trait-specific, and are they traceable to measurable non-personality factors? The latter question is of particular importance as it could also inform us about the mechanisms of mean-level changes, as discussed above.

To date, little is known about the possible correlates of personality trait changes in old age. Many of the above-mentioned life experiences that are possibly relevant at younger ages (e.g., professional success or childbirth) are not common in old age and are therefore also

less likely to be linked to personality trait change in late life. Instead, worsening physical health, cognitive decline, social losses, and increasingly-limited ability to function independently are likely to be some of the most common and overwhelming transitions in the ninth decade of life. It is therefore possible that these factors are also among the most plausible correlates of personality trait change in old age. Note that many of these factors do not reflect ageing-related *experiences* as such but rather characterize the ageing process itself. However, the logic remains the same as that regarding the previously-proposed effects of experiences (Roberts, Wood, & Smith, 2005): if people who generally age faster in a given period also show accelerated personality trait change, then mean-level personality trait change in old age may reflect ageing more generally.

### 1.2. *The present study*

Möttus and colleagues (2011) described general patterns of personality trait stability and change in LBC1921 between ages 81 and 87 and compared the findings to those found in a younger cohort over a shorter period of follow up. Examining individual change trajectories and their correlates in old age and investigating whether these can inform us with respect to causes of the normative changes represented a conceptually separate, logical next step. As far as we are aware, there are few, if any, studies to date that have investigated the factors that may be associated with personality trait change in the ninth decade of the human life-course.

First, we tested whether there were statistically significant individual differences in the changes on the latent Five-Factor Model (FFM; McCrae & John, 1992) personality traits over six years in the ninth decade of life. In general, individual differences in the FFM traits appeared to be highly but not perfectly stable over the six-year period, with the correlations between latent (i.e., free of random measurement error) personality traits measured at ages 81 and 87 years being 0.83, 0.89, 0.88, 0.78, and 0.81, respectively, for Emotional Stability, Extraversion, Intellect, Agreeableness, and Conscientiousness (Möttus et al., 2011). The

imperfect rank-order stabilities of the latent trait scores suggested possible individual differences in change trajectories.

Second, we tested to what degree individual differences in personality trait changes were intercorrelated. High intercorrelations would suggest that overlapping factors (e.g., ageing process generally) simultaneously drive the changes in different personality traits (Soto & John, 2011). In contrast, if the intercorrelations among changes resemble the correlations among general (baseline) trait levels, they probably “reflect the initial conceptual and measurement overlaps” (Soto & John, 2011, p. 23) between the traits. If so, this will suggest little common influence on changes in different personality traits.

Finally, we tested whether baseline (general) levels of old age personality traits—aggregated across measurements at ages about 81 and 87 years—and longitudinal changes in the traits over this six-year period were associated with some of the major domains of ageing and changes in them: cognition, physical fitness, and the ability to function independently in daily life. Declines in these domains are often listed among the major aspects of ageing (or age-related frailty; von Faber et al., 2001; Markle-Reid & Browne, 2003; Woodhouse & O’Mahony, 1997). In particular, it is plausible to propose that people experiencing greater declines in physical fitness (resulting in reduced mobility) also might have fewer opportunities for being sociable (implying decreases in manifest Extraversion); people who decline in physical fitness and may therefore be increasingly less able to cope with various types of tasks also might be less organized and orderly (reflected in decreases in Conscientiousness); and people experiencing greater cognitive decline also might be less interested in intellectual activities (decreases in the Intellect/Openness domain) and less able to live orderly and organized lives (declines in Conscientiousness). Alternatively, if personality trait changes are strongly correlated across the traits, we should expect similar

associations of changes in physical, cognitive and everyday functioning with changes in all personality traits. In this case, personality change would reflect ageing more generally.

## **2. Method**

### *2.1. Participants*

The Lothian Birth Cohort 1921 (LBC1921) is a study of healthy ageing in the Edinburgh area of Scotland (Deary, Whiteman, Starr, Whalley, & Fox, 2004). The LBC1921 participants, all living in the community, were recruited to the study when they were around age 79. Their personality traits were first measured by post at ages 80 to 81 years. The exact dates of completing the questionnaires were not recorded; participant age is henceforth referred to as 81. Full details of the procedure are described by Gow et al. (2005). Overall, 450 people (263 women) provided complete personality data. At ages about 86 to 87 years (henceforth referred to as age 87), 209 participants (110 women; mean age  $86.61 \pm 0.42$  at the second testing) of the 450 completed the same questionnaire in the course of a comprehensive follow up study (Starr et al., 2010). Data from the 209 returning participants was used in this study. Comparison of personality traits of those who participated at both testing occasions with those who participated only at the first occasion showed that non-returners (due to death, illness, unavailability, or unwillingness) had significantly lower Emotional Stability at age 81, significantly lower cognitive ability, grip strength, and forced expiratory volume at age 79, and significantly higher independent non-functioning score (Townsend Disability Scale) and six-meter walk time at age 79 years (Table 1). The finding that returners were physically, functionally and cognitively fitter than non-returners is typical in longitudinal ageing studies.



## 2.2. Measures

*Personality traits* were measured with the 50-item International Personality Item Pool (IPIP; Goldberg, 1999). The IPIP has ten items for each of the FFM personality traits: Emotional Stability (often called its inverse, Neuroticism), Extraversion, Agreeableness, Conscientiousness, and Intellect (akin to Openness measured in other FFM questionnaires such as the Revised NEO Personality inventory; Costa & McCrae, 1992). For each of the items, which are in sentence fragment form (e.g., “Am the life of the party”), “I” was added at the beginning so that the items would be easier to read. Participants were requested to rate how well they believed each of the 50 items described them on a 5-point Likert-type scale (very inaccurate (0) to very accurate (4)). Cronbach’s alphas for the five traits at age 81 (87) were as follows: 0.88 (0.84) for Emotional Stability, 0.85 (0.82) for Extraversion, 0.71 (0.68) for Intellect, 0.78 (0.78) for Agreeableness and 0.79 (0.71) for Conscientiousness.

*Cognitive functioning* was quantified as intelligence quotient (IQ) measured at ages 79 and 87 using the Moray House Test No. 12 (MHT), a group-test of intelligence consisting of 71 items which sum to a maximum score of 76. The test includes various types of mental tasks such as word classifications, proverbs, arithmetic tasks, spatial items and others (for a more detailed description see Deary, Whalley, & Starr, 2009; for validation information see Deary et al., 2004). The MHT was administered individually to the LBC1921 participants with a 45-minute time limit. Raw MHT scores were adjusted for ages at time of testing and converted to standard IQ-type scale with a mean of 100 ( $SD = 15$ ) based on the full sample. In the models, IQ scores at the later testing occasion were standardized relative to the mean and standard deviation of age 79 scores.

*Physical fitness* was summarized at ages 79 and 87 using a composite measure consisting of 6 meter walk time (6m), grip strength, and forced expiratory volume in 1 second (FEV1). The 6m was the time taken to walk a measured length of 6 meters at a normal pace

[at age 87, scores of four people who were clear outliers (>22sec) were removed]. Grip strength was measured with a Jamar Hydraulic Hand Dynamometer. The best of three trials with the dominant hand was used. FEV1 was measured using a microspirometer, the best of three trials being recorded. It has been shown that these three indicators of physical fitness load highly on a common factor in the LBC1921, justifying the use of a composite score (Deary, Whalley, Batty, & Starr, 2006). At age 79 (87), 6m was correlated with grip strength and FEV1 at  $r = 0.29$  (0.29) and  $0.28$  (0.32),  $p < 0.001$ , respectively and grip strength and FEV were correlated at  $r = 0.70$  (0.65),  $p < 0.001$ . Raw Cronbach's alphas for the physical fitness index were 0.69 and 0.54 for ages 79 and 87, respectively. Before averaging, all scores were standardized in relation to means and standard deviations of the age 79 measurements, and the standardized 6m scores were reversed by multiplying them by (-1), so that higher scores indicated better performance in all variables. After averaging, the fitness scores were again standardized relative to mean and standard deviation of age 79 scores.

*Independent functioning* at ages 79 and 87 was measured with the Townsend Disability Scale (TDS; Townsend, 1962). The trait measured by the TDS is sometimes also called (Instrumental) Activities of Daily Living (Fieo, Watson, Deary, & Starr, 2010) but, for the sake of clarity, we label it as independent functioning in the present article. TDS is a self-report measure that evaluates the respondent's ability to cope with nine everyday tasks including washing all over, cutting toenails, getting on a bus, going up and down stairs, doing heavy housework, going shopping and carrying bags, preparing meals, reaching an overhead shelf, and tying a good knot in a piece of string. Coping with each of the activities was rated on a 3-point scale ranging from 0 (no difficulty), 1 (can do but with difficulty), to 2 (not able to do). Internal consistency of the TDS for LBC1921 was 0.77 (Fieo et al., 2010). Ratings on all tasks were summed to give a total TDS score, with higher scores indicating lower ability to manage everyday tasks. In the models, TDS scores were converted into standard scores

using the mean and standard deviation of age 79 measurements and then multiplied by (-1) so that higher scores indicated better independent everyday functioning.

### 2.3. Statistical Analyses

*Investigating the levels of and changes in specific personality traits.* In order to reduce the number of variables in statistical models and to focus more economically on the variance common to all items measuring the same latent traits, the IPIP items were randomly aggregated into parcels. For each of the five personality domains, three parcels were created, two of them consisting of three items and one of four items. Scores of all parcels were standardized in relation to the mean and standard deviation of the respective parcel score at age 81 years.

Identical Latent Growth Models (LGM) were then constructed for each of the personality traits (see Figure 1). In the LGM models, personality traits at ages 81 and 87 years were represented as latent traits defined by the three item parcels from the appropriate ages. It has previously been shown in the same sample that the measurements of the five personality traits with the IPIP at ages 81 and 87 are generally invariant over time (Möttus et al., 2011). Based on that, loadings of the IPIP parcels on the latent traits, as well as their intercepts and residual variances were constrained to be equal at ages 81 and 87 years (that is, the latent traits were defined in exactly the same way at both ages). Residual variances of corresponding IPIP parcels were allowed to co-vary over time but the parcels' residual variances were not allowed to be correlated within testing occasions, as shown in Figure 1. The intercept terms of the LGM models were defined by the latent trait scores at ages 81 and 87, while the slope terms were defined only by the age 87 latent trait scores. To scale model estimates, intercept means were fixed to 0 and variances to 1. With only two data points available, the word 'slope' is, of course, not strictly accurate, but we use it because it is generally familiar to most people. For better convergence, residual variances of latent

personality traits as defined by parcels were set to zero, so all their (presumably reliable) variance was transmitted to intercept and slope terms.

Next, the multivariate associations of IQ, physical fitness, and TDS (henceforth referred to as ageing-related variables) with personality traits and their changes were estimated (as is shown in Figure 1). Like personality traits, the ageing-related variables were measured at two time-points and subsequent measurements were expected to be correlated (see Table 1 for the observed correlations). In order to make the subsequent measurements of the ageing-related variables (e.g. IQ at age 87) represent change from their previous measurement (i.e. IQ at age 79) rather than reflecting simultaneously both previous level and change, subsequent levels were regressed on the previous levels (see Figure 1). Then, to estimate the associations of the ageing-related variables with the baseline levels of personality traits in the ninth decade of life, the personality trait intercept terms were regressed on IQ scores, physical fitness, and TDS measured at age 79 (Figure 1). To estimate the effects of the ageing-related variables on the changes in personality traits in the ninth decade, the personality trait slope terms were regressed on all of the ageing-related variables at age 79 and changes in them to age 87. All ageing-related variables were allowed to be intercorrelated and so were the changes in these variables (see Table 2 for univariate correlations).

Finally, both the intercept and slope terms of personality traits were regressed on sex (men coded as 1 and women coded as 2) to account for possible sex differences in baseline personality trait levels and their changes. Also, physical fitness at age 79 was regressed on sex to account for sex differences in this trait (physical fitness at age 79 was the only ageing-related variable that was significantly related to sex).

Although multiple associations were tested, we used the traditional 5% alpha level throughout. We acknowledge that this increased the risk of type 1 errors. However, with the

relatively small sample size and expected modest effect sizes, adapting stricter alpha levels would have increased the likelihood of type 2 errors. We believe that the validity of any associations is more accurately tested by future replication studies (Lykken, 1968) than by relying on strict alpha levels that may preclude discovering potentially interesting findings in the first place.

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Figure 1 about here

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### **3. Results**

#### *3.1. Descriptions of the raw scores*

Mean-level changes in latent personality traits for this sample were reported by Möttus and colleagues (2011). For reference, however, means and standard deviations of all unweighted personality trait scores are shown again in Table 1 along with raw scores of ageing-related variables. For four of the five personality traits mean scores declined significantly over the six-year period but there was no such change in Emotional Stability. Among the ageing-related variables, IQ, lung function (FEV1), grip strength and composite physical fitness scores decreased significantly, and six-meter walk time and independent non-functioning (TDS) scores increased significantly between ages 79 and 87. So there was clear evidence for general declines in what are considered to be major domains of ageing—cognition, physical fitness and independent functioning—over the six-year period. Also, the variability of six-meter walk time, physical fitness and independent functioning scores increased substantially. That is, in addition to general declines, differences among people in physical health (especially in its mobility aspect) and daily coping were much larger at age 87 compared to age 79 years.

The rank-order stability of ageing-related variables—cognitive ability, physical fitness, and independent functioning—was generally not higher than that of personality traits, which

suggests at least comparable individual differences in the rates of change. The rank-order consistency was relatively lower for independent functioning, being  $r = 0.51$ ,  $p < 0.001$ .

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Table 1 about here

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### *3.2. Associations among the ageing-related variables*

Intercorrelations among the ageing-related variables at age 79 are given in Table 2. Physical fitness was significantly albeit modestly associated with IQ but more strongly correlated with independent functioning ( $r = 0.39$ ,  $p < 0.001$ ). To estimate the intercorrelations among the changes in these variables between ages 79 and 87, the later measurements were residualized for the previous measurements using linear regression and correlations between the residuals were calculated (Table 2). Changes in IQ, independent functioning, and physical fitness were significantly intercorrelated, especially changes in the latter two ( $r = 0.56$ ,  $p < 0.001$ ). Higher age-79 IQ was modestly associated with less decline in physical fitness and higher physical fitness at age 79 predicted less decline in independent functioning.

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Table 2 about here

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### *3.3. Trends in personality trait changes*

The slope means and variances, obtained from the LGM models that did not include any age-related variables are reported in Table 3. The slope means are consistent with results in Table 1 and Möttus and colleagues (2011), showing significant declines for all personality traits except Emotional Stability. The most important result, however, is that there were significant variances in slope terms, suggesting enough individual differences in personality trait changes to merit further investigation. Of course, individual differences in personality trait changes were much smaller than differences in baseline (general) trait levels: slope

variances varied between 25.6% and 35.0% of intercept variances for the five traits (because the intercept variances were set to 1, the slope variance estimates are effectively percentages).

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Table 3 about here

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Intercorrelations among slope factor scores (personality trait changes) are reported in Table 4, along with intercorrelations among intercept factor scores (baseline levels of personality traits), and correlations between the intercept and slope factor scores. Generally, there were several significant intercorrelations among the slopes, but they were modest in size and generally similar to correlations among intercepts, albeit often slightly weaker. None of the correlations among slopes was significantly different from the corresponding correlations among intercepts. That is, changes in personality traits were not intercorrelated differently than the baseline trait levels (similar findings were reported by Allemand, Zimprich, & Martin, 2008; Soto & John, 2011). Intercept and slope scores were significantly negatively correlated (similarly to Small et al., 2003; Allemand et al., 2008), possibly suggesting some regression to the mean effect in personality trait changes.

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Table 4 about here

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### *3.4. Predictors of baseline (general) personality trait levels and their changes*

For all personality traits, the LGM models with co-variables fitted the data acceptably well: the Comparative Fit Indices (CFI) were all at least 0.95 or higher, and Root Mean Square Errors of Approximation (RMSEA) were lower than 0.08. Model fit indices are given in Table 5, along with parameter estimates for the ageing-related variables that were used to predict baseline personality trait levels (intercepts) and personality trait changes (slopes).

Generally there were only a few statistically significant associations between IQ, independent functioning and physical fitness, changes in them and personality traits or

changes in them. With regard to baseline personality trait levels, higher age 79 IQ predicted higher Intellect and lower Extraversion in the ninth decade. Additionally, women had significantly higher general levels of Agreeableness. As for personality trait change, only changes in Conscientiousness were associated with any ageing-related variables. Specifically, higher age 79 IQ predicted more positive change scores in Conscientiousness, meaning that those with higher baseline IQ scores tended to decline less, stay the same or increase in Conscientiousness in their ninth decade of life. Additionally, declines in physical fitness were correlated with declines in Conscientiousness scores, meaning that being in relatively better physical shape at age 87 compared to age 79 predicted less or no decline, or even increases, in Conscientiousness over 6 years in the ninth decade of life.

Since IQ, independent functioning, physical fitness, and changes in them were often correlated it was possible that, when simultaneously predicting personality trait levels and changes in them, they may have ‘consumed’ each other’s shares in the outcomes. For this reason, we also ran additional models whereby only one type of predictor (IQ and its change, independent functioning and its change, or physical fitness and its change) was included in the model at a time. The results were similar to the models with all predictors included: the single notable difference was that declines in independent functioning scores were significantly associated declines in Emotional Stability ( $b = 0.06$ ,  $p < 0.05$ ) in the model which did not include IQ and physical fitness.

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Table 5 about here

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#### 4. Discussion

In the present study, we focused on personality trait development the ninth decade of life, an under-explored period of life-span personality trait development.

##### *4.1. Correlates of the baseline personality trait levels*



Before discussing personality trait changes in the ninth decade of life, we address the associations among baseline personality trait levels and other variables. Higher cognitive ability at age 79 was associated with lower baseline levels of Extraversion and higher baseline levels of Intellect in the ninth decade of life and women were about 0.75 standard deviation higher in Agreeable than men. The positive relation between cognitive ability and Intellect (Openness) is well documented in younger ages (Ackerman & Heggestad, 1997), and probably reflects the life-long co-variation of these traits. The negative association between cognitive ability and Extraversion, in contrast, is not a typical finding, tentatively suggesting that higher age-79 cognitive functioning may limit manifestation of Extraversion in later life. Why this would be the case is difficult to explain. In younger ages, it has been well established that women tend to score higher on Neuroticism (i.e. lower on Emotional Stability) and Agreeableness (Costa, Terracciano, & McCrae, 2001) and there is also at least one study showing these differences to be present at older age (between ages 65 and 98; Chapman, Duberstein, Sörensen, & Lyness, 2007). The results of this study confirmed these findings only partially: the expected sex difference was present in Agreeableness but not in Emotional Stability. This may mean that among those who have lived to very old age, being exclusively older than 80 years, the tendency to feel negative emotions may have equalized between men and women, at least in this sample.

#### *4.2. Personality trait changes*

With respect to personality trait development in the ninth decade of life, the first important result was that there were significant individual differences in changes in all personality traits between ages 81 and 87. That is, although there were substantial mean-level changes in personality traits over this period (Möttus et al., 2011), not everyone changed in the same ways. This justified the need to investigate the general mechanisms (correlated vs trait-specific changes) of and particular contributors to those changes. The second important

result was that correlations among the changes in different personality traits were similar to correlations among baseline trait levels, although often slightly weaker. This suggested that the correlations among trait changes may have merely reflected the conceptual and measurement overlaps between the traits in general that had already been observable for baseline trait levels. Similar findings have been previously reported for people at less advanced ages (Allemand et al., 2008; Soto & John, 2011). Together these findings provide little evidence for a single general mechanism that accounts for changes in different personality traits (Soto & John, 2011), neither in middle adulthood nor in older age. As the third important result, individuals' personality trait change trajectories were in most cases independent of their differences in the considered major domains of ageing and declines in these domains over time. Conscientiousness, however, was an exception: people with higher age-79 IQs and/or relatively smaller decreases in independent functioning to age 87 did not decline, declined less, or even increased in Conscientiousness.

The finding that higher age-79 IQ was associated with lower decline in Conscientiousness may suggest that better cognitive functioning offers a means for maintaining previous levels in this personality trait. It might be argued that, among the five FFM personality traits, Conscientiousness (being orderly, organized and dutiful) is the one for which the manifestation demands the most mental effort and vigour: better cognitive baseline functioning may help to sustain the needed vigour through its possible beneficial effect for developing a functional repertoire of habits that help to keep a level of order and organization even in very old age. However, similar logic might be argued for Intellect as maintaining the level of this trait may also call for a functional repertoire of relevant habits, which could be fostered by better baseline cognitive functioning. The fact that no correlation between baseline cognition and changes in Intellect over time was observed may therefore undermine our explanation for the association between the age-79 IQ and change in

Conscientiousness. The correlated changes between physical fitness and Conscientiousness are perhaps also explicable: if people's strength and ability to move around declines, it will be increasingly difficult to sustain an orderly and organized life-style. Alternatively, of course, it is possible that decreased Conscientiousness led people to invest less in keeping them fit. In the latter case, the association mirrored well-established and potentially causal links between Conscientiousness and physical health outcomes including mortality (Kern & Friedman, 2008).

The findings that individual differences and declines in the major domains of ageing played roles only for Conscientiousness are somewhat surprising. Given the significant individual differences in the changes in all personality traits, we expected to see evidence for people also having differentially adjusted other aspects of their personalities (e.g., Extraversion and Intellect, in addition to Conscientiousness) to relative losses of physical fitness, independent functioning, or cognition. Table 1 showed that mean independent functioning and physical fitness scores declined substantially over the six-year period and that standard deviations of those variables increased up to four times. Likewise, the rank-order-stabilities of these variables were far from perfect. This suggested that, in general, much happened in the domains of health and everyday coping in the ninth decade of life, but even more importantly for the present purposes, individuals obviously differed in the extent of declines. Thus, the preconditions were fulfilled for all hypothesized associations.

This leaves us with at least three possible explanations. First, it may be that personality trait development in old age does not reflect ageing process in a general manner as hypothesized. Instead different aspects of ageing or experiences related to the ageing process may contribute to development of different personality traits. The finding that changes were not correlated across different traits also supports this possibility. The aspects of ageing process that were considered in this study happened to be relevant for Conscientiousness but

not for other personality traits: future studies may find that different ageing aspects or experiences are implicated in the development of other personality traits. Social losses (e.g., death of spouse or close friends) that are also integral parts of the ageing process constitute one example of the factors that may be considered in future research. Second, it is possible that changes in personality traits and/or ageing-related variables were not captured with sufficient degrees of reliability and validity to detect the (possibly small) effects. Third, the sample used in this study may have been too small to detect the associations between personality trait changes and ageing-related variables reliably.

As a corollary to the study, we observed that individual differences in objectively measured physical fitness and self-reported ability to cope with tasks of daily living (independent functioning) and, especially, changes in them were moderately to strongly associated. This finding is not surprising: physical constraints are expected to set limits to ability to independently cope with everyday tasks.

#### *4.3. Strengths and limitations*

The primary strength of the study was that it was one of the first—if not the first—attempts to investigate the general vs trait-specific mechanisms of and possible contributors to personality trait changes in the ninth decade of life, an age level which becomes increasingly represented in populations. Another important strength was that the sample represented a narrow age cohort, meaning that personality traits and their changes could be associated with very specific ages rather than with non-specific ‘old age’, and that the relationships were not confounded by variation in chronological age.

The study also had limitations. Although the sample was valuable in its uniqueness it was modest in its size, limiting the statistical power to trace personality trait change reliably to the selected predictors. Given the subtle nature of individual personality trait change trajectories (on the background of generally high rank-order stability) their possible

associations with predictors were not necessarily strong to start with, meaning that we may have missed some true effects as they appeared non-significant due to their relative weakness (type 2 errors). In contrast, the associations that appeared as significant may also have been type 1 errors, especially considering the number of effects tested. In the under-explored area of personality trait development in old age, however, we think that type 1 errors are not necessarily a bigger problem than type 2 errors. If potential associations are reported then future studies will be able to show if they replicate or not. If any, presumably small, true effects are missed as a result of strict criteria for statistical significance, there will be nothing for future studies to replicate and these small associations may remain undiscovered. Fortunately, most of the few associations reported here (e.g., higher cognitive ability and less decline in physical fitness were associated with declines in Conscientiousness) appear theoretically explicable, which makes them less likely to be type 1 errors.

Another limitation is that personality trait changes were represented using only two time-points. More time-points would have provided more reliable information about individual personality change trajectories. In the current model specification, the change scores (slopes) may have to some extent reflected regression to the mean: the negative correlations between the intercept and slope scores (Table 4) speak to this concern. This was partially compensated by modelling personality traits as latent variables, which were presumably less affected by measurement issues. The fact that ageing-related variables were not specified as latent growth model variables, due to sample size and the lack of more than two data points, may also be seen as a limitation. Although we chose to model the ageing-related variables and changes in them as predictive of personality traits and their changes (partly because the ageing-related variables had initially been measured about two years prior to the first and eight years prior to the second assessment of personality traits), possibilities of alternative causal directions have to be acknowledged.

#### *4.4. Conclusions*

In summary, the results of the present study are only to a modest extent consistent with the hypothesis that the significant changes in personality trait levels in the ninth decade of life reflect ageing process more generally. First, there was no evidence for changes in different personality traits being intercorrelated and therefore possibly sharing contributors. Second, people's levels of physical fitness, cognition, and ability to function independently and changes in these levels—arguably important aspects of ageing in the ninth decade of life—were on most cases independent of individuals' personality trait change trajectories. That being said, declines in Conscientiousness were associated with some of these domains of ageing. Therefore, although the contributors to personality trait development in old age apparently mostly lie elsewhere than in the ageing process more generally, at least in this sample, there seemed to exist factors that could be meaningfully traced to individual differences in personality trait change. If so, this can inform us about the sources of mean-level changes such as declines in Conscientiousness. Future studies in this age group may benefit from testing other possible correlates of personality trait changes. For instance, important social losses such as deaths of spouses, relatives or close friends may be relevant for personality trait change in late life.

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*Table 1.* Means and standard deviation of the raw scores of study variables (and the composite physical fitness index) along with mean-level changes, rank-order stabilities and attrition effects.

	<i>M</i> age 81 (79)	<i>SD</i> age 81 (79)	<i>N</i> age 81 (79)	<i>M</i> age 87	<i>SD</i> age 87	<i>N</i> age 87	<i>d</i>	<i>t</i> (df)	<i>r</i>	<i>d<sub>attr</sub></i>
Emotional Stability	25.51	7.93	209	24.91	7.39	209	-0.08	-1.57 (208)	0.75	0.28
Extraversion	20.87	7.54	209	19.39	7.19	209	-0.20	-4.09 (208)	0.75	0.05
Intellect	23.81	5.35	209	22.88	5.52	209	-0.17	-2.95 (208)	0.65	0.07
Agreeableness	32.00	4.95	209	30.84	4.92	209	-0.24	-4.00 (208)	0.64	0.06
Conscientiousness	29.26	6.12	209	27.48	5.93	209	-0.30	-5.35 (208)	0.68	0.14
Townsend Disability Scale	1.76	2.14	208	4.00	4.00	205	0.70	9.51 (203)	0.51	-0.28
Cognitive ability (IQ)	104.53	12.21	206	100.72	14.34	181	-0.29	-4.49 (178)	0.70	0.42
Six-meter walk time	4.30	1.24	207	6.15	2.56	169	0.92	11.28 (166)	0.45	-0.38
Forced expiratory volume	2.01	0.59	208	1.78	0.54	184	-0.41	-10.52 (182)	0.87	0.32
Grip strength	28.17	9.45	208	21.64	8.58	183	-0.72	-17.55 (181)	0.84	0.33
Physical fitness	0.00	1.00	207	-1.04	1.27	166	-0.91	-17.31(163)	0.76	—

NOTE: *M* = mean; *SD* = standard deviation; *N* = number of participants with valid score; *d* = Cohen's *d* reflecting mean differences between age 81 (79) and age 87 scores; *t* = statistic from the paired sample *t*-test comparing age 81 (79) scores to age 87 scores [all associations were significant at  $p < 0.001$ , except for Emotional Stability ( $p = 0.12$ ) and Intellect ( $p < 0.01$ )]; df = degrees of freedom; *r* = correlation between age 81 (79) and age 87 scores (all significant at  $p < 0.001$ ); *d<sub>attr</sub>* = Cohen's *d* comparing participants whose personality traits were tested at ages 81 and 87 (higher values) to those who only participated at age 81 [the measurements were taken at age 81 (or 79 in case of ageing-related variables); in case of  $|d| = 0.28$ ,  $p < 0.01$ ; in case of  $|d| \geq 0.32$ ,  $p < 0.001$ ]; IQ = intelligence quotient; Physical fitness = composite physical fitness index (standardized in relation to age 79 scores). Standardized six-meter walk time values were multiplied by (-1) before including them into the physical fitness index.

*Table 2.* Correlations between ageing-related variables at age 79 years and changes in them to age 87 years.

	1	2	3	4	5
1. IQ at age 79					
2. Independent functioning at age 79	0.11				
3. Physical fitness at age 79	0.15*	0.39*			
4. IQ $\Delta$	0.00	0.01	-0.08		
5. Independent functioning $\Delta$	0.03	0.00	0.26*	0.16*	
6. Physical fitness $\Delta$	0.16*	0.01	0.00	0.16*	0.56*

NOTE: IQ = intelligence quotient;  $\Delta$  = changes in IQ/independent functioning/physical fitness between ages 79 and 87. \*  $p < 0.05$  (correlations higher than 0.25 are significant at  $p < 0.001$ ).

*Table 3.* Slope means and variances for personality traits.

	Slope mean	Slope variance	Between-individuals variance	Within-individuals variance
Emotional Stability	-0.07	0.29	77.5%	22.5%
Extraversion	-0.18	0.26	79.4%	20.6%
Intellect	-0.18	0.35	74.1%	25.9%
Agreeableness	-0.21	0.34	74.6%	25.4%
Conscientiousness	-0.26	0.25	80.0%	20.0%

NOTE: All estimates are standardized in relation to first measurement (i.e., intercept means were set 0 and standard deviations to 1). All estimates are significant at  $p < 0.001$  except for the slope means for Emotional Stability ( $p = 0.12$ ) and Intellect ( $p < 0.01$ ).

*Table 4.* Correlations among and between personality trait intercept and slope factor scores.

	1	2	3	4	5
1. Emotional Stability	-0.43*	0.31*	0.07	0.12	0.27*
2. Extraversion	0.22*	-0.42*	0.21*	0.46*	0.15*
3. Intellect	-0.02	0.22*	-0.32*	0.22*	0.18*
4. Agreeableness	0.13	0.30*	0.14*	-0.40*	0.24*
5. Conscientiousness	0.20*	0.13	0.18*	0.17*	-0.46*

NOTE: Correlations among slopes are below and correlations among intercepts are above the diagonal. Correlations between the intercepts and slopes (in italics) are on the diagonal. \*  $p < 0.05$  (correlations higher than 0.17 were significant at  $p < 0.01$  and correlations higher than 0.22 were significant at  $p < 0.001$ ).

Table 5. Latent Growth Model results for the five personality traits: predictors of baseline personality trait levels (intercepts) and personality trait changes between ages 81 and 87 (slopes).

	Emotional Stability		Extraversion		Intellect		Agreeableness		Conscientiousness	
	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>	<i>b</i>	<i>p</i>
<i>Intercepts</i>										
IQ age 79	0.085	0.264	-0.155	0.042	0.199	0.013	-0.012	0.882	-0.127	0.104
Independent functioning age 79	0.157	0.064	0.050	0.556	0.009	0.917	-0.041	0.643	0.000	0.997
Physical fitness age 79	-0.080	0.501	0.020	0.863	0.094	0.442	0.048	0.692	0.015	0.904
Sex	-0.189	0.390	0.288	0.189	0.081	0.720	0.754	0.001	-0.024	0.916
<i>Slopes</i>										
IQ age 79	0.038	0.559	-0.048	0.478	-0.008	0.920	-0.009	0.912	0.170	0.018
IQ $\Delta$	0.000	0.998	0.029	0.600	-0.023	0.738	0.059	0.367	-0.068	0.252
Independent functioning age 79	-0.073	0.227	-0.003	0.955	0.073	0.332	-0.028	0.708	0.041	0.523
Independent functioning $\Delta$	-0.055	0.148	0.015	0.702	-0.032	0.523	0.006	0.888	-0.009	0.819
Physical fitness age 79	-0.120	0.214	0.021	0.832	-0.060	0.631	0.015	0.901	-0.166	0.113
Physical fitness $\Delta$	0.031	0.658	-0.018	0.810	0.039	0.681	0.043	0.611	0.161	0.033
Sex	-0.028	0.837	-0.096	0.486	0.140	0.416	-0.104	0.543	-0.092	0.538
<i>Model fit indices</i>										
$\chi^2$	90.245		87.000		99.840		106.727		101.245	
df	53		53		53		53		53	
CFI	0.97		0.97		0.95		0.95		0.96	
RMSEA [90% CI]	0.058 [0.037; 0.078]		0.055 [0.033; 0.076]		0.065 [0.045; 0.084]		0.070 [0.050; 0.089]		0.066 [0.046; 0.085]	

NOTE: *b* = estimates standardized relative to first measurements (except for sex where 1 stands for men and 2 for women); Intercept = latent variable representing the general level of personality traits; IQ = intelligence quotient; Slope = latent variable representing personality trait change;  $\Delta$  = changes in IQ/independent functioning/physical fitness between ages 79 and 87;  $\chi^2$  = chi-square; df = degrees of freedom; CFI = Comparative fit index; RMSEA = Root mean square error of approximation [90% confidence intervals]. For precision in reporting the main findings, estimates are rounded to the third decimal place.



**Figure captions.**

Figure 1. Latent Growth Model (LGM) with time-varying covariates predicting personality trait levels (intercept) and change in them (slope). Parcel = averages of three or four personality items. Intercept, slope and physical fitness at age 79 were also regressed on sex. Similar models were constructed for all Big Five traits. IQ = intelligence quotient. Solid lines indicate regression coefficients, dashed lines indicate correlations.

Figure 1.

